Glass and Ceramics Vol. 63, Nos. 3 – 4, 2006

UDC 666.3-413:66.046

OPTIMIZATION OF THE CONTENT OF LIGHT FRACTION ASH IN CERAMIC TILE MIXTURES

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Translated from Steklo i Keramika, No. 3, pp. 26 – 27, March, 2006.

Using the linear regression method it is established that the optimum content of light-fraction ash in ceramic mixtures for producing facade tiles from technogenic waste without traditional natural materials is 47 – 48%.

The production of ceramic building materials is one of the most material-consuming sectors of industry. Therefore, rational utilization of fuel, natural minerals, and other materials is becoming a crucial factor in the progress of this sector. In this context the problem of using technogenic materials in ceramics is quite topical.

We have shown in [1, 2] a fundamental possibility of using the gravitation tails of zircon-ilmenite ore (GZIO) as the argillaceous component and using light fraction ash (LFA) as the flux and grog component in the production of ceramic tiles. The production of facade tiles from these technogenic waste without traditional natural materials was described in [3].

For the purpose of optimizing the LFA content in ceramic mixtures for facade tiles (regarding their strength) we investigated mixtures listed in Table 1.

We studied tiles of size 100 × 100 × 10 mm produced by semidry molding under a unit pressure of 20 MPa. Dried tiles of different compositions were fired at 1080°C. Their physicomechanical parameters are listed in Table 1.

The linear regression method [4] was used to study the correlation between the LFA content and the bending strength of ceramic tiles. This method makes it possible to identify the effect of changes of one variable on the other variable. Such model is constructed on experimental results and describes analytically the dependence of data obtained in a series of experiments.

The molding pressure and the firing temperature remained constant during the experiments; therefore, they did not affect the results obtained. Consequently, the determinant factor with respect to the quality of facade tiles in this case is the content of LFA in the mixture, i.e., the parameter X. During the experiment the parameter X varied from 10 to 70% (Table 1).

The bending strength of samples after firing, i.e., the parameter Y varied from a minimal value (36.8 MPa) to a maximum (45.4 MPa).

The first-order linear equation of the model has the following form:

$$Y = aX + b,$$

where a is the factor of the independent variable X and b is the free regression member.

To intensify the correlation between the experimental data and the data obtained from the model, we additionally formulated and analyzed regression equations of the second – sixth orders. We decided to stay with the fourth-order regression equation, which describes the most adequately the experimental results:

$$Y = 3 \times 10^{-7}X^4 - 0.0002X^3 + 0.0211X^2 - 0.5453X + 40.471.$$

The calculated (predicted) values of the response function and the values of the residues, i.e., the difference between the actual and calculated values, are listed in Table 2.

Comparing the residues in Table 2, it can be stated that the data obtained from the regression model using the fourth-order equation are closer to the experimental values,

TABLE 1

Ceramic mixture	Weight content %: GZIO tails	Weight content %: LFA	Properties of samples: bending strength, MPa	Properties of samples: water absorption, %	Properties of samples: cold resistance, cycles
1	90	10	36.8	4.20	487
2	80	20	37.2	3.92	498
3	70	30	38.1	3.70	502
4	60	40	40.2	3.58	514
5	50	50	45.4	3.26	518
6	40	60	43.4	3.30	515
7	30	70	42.8	3.50	510

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0361-7610/06/0304-0095

TABLE 2

Experiment*	Values calculated based on regression equation			
	of the first order		of the fourth order	
	Y	residue	*Y*	residue
1	36.518	0.282	36.963	– 0.163
2	37.864	– 0.664	36.646	0.554
3	39.211	– 1.111	38.431	– 0.331
4	40.557	– 0.357	41.163	– 0.963
5	41.904	3.496	43.624	1.776
6	43.250	0.150	44.532	– 1.132
7	44.596	– 1.796	42.541	0.259

* The number of experiment corresponds to the number of the experimental mixture.

since for most experiments the residues have become smaller. This is additionally corroborated by the determinancy coefficient: in the second model ($R^2 = 0.914$) it is closer to unity than in the first model ($R^2 = 0.745$).

A graphical interpretation based on the model indicates that the bend point correlated with the maximum strength corresponds to the LFA content between 47 and 48% (Fig. 1, curve *1*).

Thus, the optimum content of light fraction ash in ceramic mixtures for producing facade tiles from technogenic materials without traditional natural minerals is 47 – 48%.

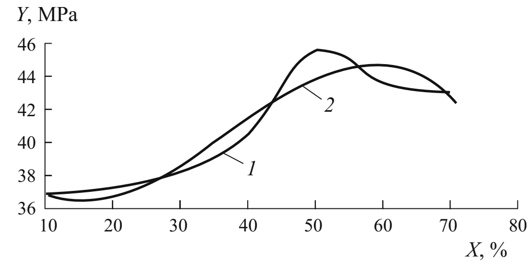

Fig. 1. The effect of the content of LFA on bending strength *Y* of ceramic tiles: *1*) experimental data; *2*) values obtained using a fourth-order model.

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